PostDoc activities suggested by the DTU Global Decision Support Initiative (GDSI) Beskrivelse af post.docs

PD DTU Transport 1:
Transferred Uncertainties in Demand and Transport models: Decision Support and Project evaluation

Traditionally, Danish transport investment decisions are based on cost-benefit analysis (CBA) converting the impacts such as pollutants, accidents, time savings etc. into monetary units. The virtues (pros) of a project are set against the deficiencies (cons) of the project making it possible to calculate investment criteria that can be used in the decision-making. However, these deterministic single point output criteria are based upon “best guess” estimates of each input variable to the model. Therefore it is relevant to treat issues of uncertainty relating to CBA and transport evaluation. Transport model output, such as modelled traffic and derived measures, and demand forecasts, is a key input for CBA namely as regards travel time savings and hence the consumer surplus. However, when modelling complex infrastructure systems, both input and output are subjected to a substantial degree of uncertainty which can cause severe under- and overestimations of benefits and costs made use of in the CBA. This dramatically reduces the reliability of the CBA results. The suggested activity continues current research within the area of demand and cost inaccuracies taking part of the UNITE (Uncertainties in Transport Project Evaluation) project. When considering, for instance, the definition of the model context boundaries, the data collection process, and the parameter calibration of the stochastic variables, they all contain a certain degree of uncertainty which is reflected in the model output. It is therefore of vital concern to clarify the consequences and effect inaccurate demand forecasts pose to the results produced from the CBA and whether it in fact are embedded within traffic model calculations.

PD DTU Transport 2:
Use and Influence of Decision Support in Policy making

Decision support tools are only relevant if they are applied in planning and policy making and if the results of such tools influence decisions. Recent research has, however, demonstrated that decision support may be used in situations where the influence is limited or that the use and influence differs from and takes other forms than expected. The roles of decision support e.g. vary from instrumental to conceptual and symbolic as well as combinations of these roles. Many factors impact on the use and influence of knowledge such as the decision support tool and knowledge itself (adequacy, credibility, timeliness), the institutional and political context (jurisdictional level, degree of consensus, the institutionalization of the political field) as well as connections between knowledge producer and recipient (dissemination, similarity in education, trust). For transitions towards sustainability in modern complex societies use of integrated decision support tools are crucial to provide relevant and important knowledge. However, also use and influence of knowledge on sustainability is not always applied and influential in actual policymaking or they influence in manners not anticipated. The post doc will focus on conditions that facilitate or impede application and influence of decision support for sustainability. Comparative analyses across different sectors and institutional settings will provide valuable knowledge and can contribute to the design of tools, provision of adequate institutional set-up as well as strengthening of relations between producers and users of decision support.

PD DTU Transport 3:
Sustainability Metrics for Transport
Transport is one of the sectors that is most challenged by the sustainability agenda due to its strong dependence on fossil fuel resources, intrusive infrastructure networks, large scale capital investments, sundown industrial systems, and ineffective governance structures. The transition towards more sustainable transport systems and services will require the support of comprehensive metrics regarding technological and institutional performance of transport system across the environmental, social, economic, and governance domains. Existing operational metrics on transport systems are typically confined to singular performance domains (e.g. traffic safety), or subsectors (e.g. railway punctuality; road pavement conditions), whereas more comprehensive systems of sustainable transport indicators and performance measures are only advanced at the conceptual level. Research is needed to connect conceptual and operational aspects of sustainable transport metrics, for application within transport planning and management. Particular application contexts of contemporary interest include Sustainable Urban Mobility Plans (SUMP) and National Sustainable Transport Planning (NSTP).

PD DTU Transport 4:
Sustainable Development in a Planning context
The transport area in Denmark is subject to massive investments in these years ranging from investments in infrastructure, public transportation, Green Technology and ITS. From an official hold, there is a huge focus on sustainability, green technology and a modal shift towards public transportation, however, this focus seems to get lost somewhere in the process between visioning and implementing. As it appears from the quotes, transport policy is affecting us all and is therefore a very delicate and highly political issue to fiddle with. This has been experienced by many a politician and colloquially it is known that promises of transport infrastructure have been used to secure election (or the opposite), even in the most rural parts of the country. So what does it then take to advance the sustainable development agenda in transport planning? For several reasons the planning processes seem to follow a business-as-usual strategy that overrules every good intentions of considering a changed framework for future transport development. No space is left to consider solutions that will make these tens of thousands of people less dependent on their cars. Furthermore the planning is assigned to a paradigm and a set of values that makes it unable to meet and adapt to new requirements for a changed behaviour. This post doc will seek to bridge the gap between planning processes, economy, political decision making and Sustainable development. A key concern is to link and operationalise sustainability in a planning context thus to challenge the normal set of values and approaches to appraisal by questioning some of the fundamental elements of the “traditional Cost-benefit analysis” and thereby encourage a different approach based on a set of norms in line with sustainable development.

PD DTU Civil Engineering 1
Risk informed decision support on crowd management
In the research project, tools mathematically modeling and for simulating crowd movement in evacuation scenarios will be developed; this important for safety design. The focus of the research project will be particularly on the study of complex boundaries, e.g. large buildings, transportation environments (bridges, tunnels, metro stations) and also of behavioral aspects that are not currently fully addressed in current evacuation models, e.g., behaviors of mixed and vulnerable populations. The development of robust models to predict human behavior in emergency evacuations will start from the analysis of the currently available real world data (i.e., experiments and actual fires) and from the

limitations of the existing evacuation models. The project will start with a review of the literature concerning evacuation models employing different modeling assumptions (e.g., stochastic models, fluid models, agent-based models, etc.).
Safety design requires tools able to predict crowd movement and patterns and incorporate, in the case of fire evacuations, the influence of the smoke on human behavior. For this reason there is a need to develop and validate specific sub-models aimed to simulate specific people performances.
After the validation process, the new models will be embedded in the framework of existing open source evacuation models, in order to improve their usability and the diffusion of the results produced. The verification of the embedded sub-models will be then performed for a set of general case-studies. The scope of the research project is to increase the knowledge on an intrinsically challenging problem, namely Human Behavior in Fire, and give practitioners and engineers reliable and robust tools for improving fire safety design.

PD DTU Civil Engineering 2
Probabilistic modeling of smart buildings as systems within the grid system
This research project is dedicated to establish a holistic and consistent probabilistic model of buildings as a system in itself. The developed model should account for all known factors which have an influence on energy consumption, energy emissions, indoor climate, building health and personal comfort, ranging from choice of building envelope, geometry and window solutions, over ventilation systems and energy storage systems to smart monitoring and control systems and occupant behavior. The development of such a probabilistic would point at new possibilities for optimizing energy management of building and also identify needs for new technical developments – innovation.
Based on the model, energy renovation strategies as well as new building design concepts can be developed, assessed and optimized. The aim and objective of this research is not limited establish better knowledge and decision basis for designing and/or renovating buildings – but moreover to facilitate the development of an improved decision basis for grid design and design of smart cities in which the individual buildings comprise both demand, storage and supply of energy – and constitutes a major player in terms of emissions.

PD DTU Byg 3
Probabilistic modeling in geology / rock mechanics
Bjergartsmekanik beskriver de ændringer faste bjergarter undergår, når de udsættes for ændrede spændingsforhold og ændret porevæske. Emnet har i dansk sammenhæng specielt været dyrket i forbindelse med reservoirbjergarters opsprækning eller kompaktion i forbindelse med poretryksændringer under kulbrinteproduktion, eller som følge af ændret porevæske f.eks. i forbindelse med vandinjektion. Formålet med den påtænkte aktivitet er at generalisere og udvikle den bjergartsmekaniske teoriramme, der er relevant i forbindelse med byggeri på eller i faste bjergarter, som for eksempel Københavnskalk. I næsten alle anvendelser af bjergartsmekanik er der kun adgang til begrænset information om bjergarternes fysiske egenskaber, fx gennem stikprøver i boringer, eller ved indirekte geofysiske målinger. Vi vil på den baggrund udvikle en probabilistisk formulering af bjergartsmekanikken, der kan indregne disse usikkerheder på en konsistent måde til brug ved risikovurderinger og økonomiske prognoser.

PD DTU Civil Engineering 4

Probabilistic framework for multi-scale mechanical testing

In structural engineering and mechanics the ultimate task is to identify decisions which ensure that the intended functions of structures and buildings are maintained at an adequate level of reliability and, with a sustainable service life perspective, such that resource consumption and costs are minimized, and the risk to human lives and impacts on the qualities of the environment are acceptable. To achieve this a thorough understanding of the performance of structures is required as well as how this performance depends on the design, the choice of materials, the use of the structure, the implemented maintenance strategies as well as the environmental and chemical environment the structures are exposed to. This understanding may be achieved through theoretical, mathematical modeling. Recently it was realized that structures and buildings in general may be modeled through a hierarchical ordered set of interrelated sub-systems each representing the performance of the structure at different scales, ranging from full scale (e.g. the entire structure regarded as an assembly of structural elements), over the meso-scale (e.g. cross sectional properties) to the micro-scale (e.g. material grains and their interfaces). The fundamental idea behind multi-scale testing is that if such experiments are performed at different scales they can be interlinked in consistent modeling at all scales and utilized – through probabilistic modeling and systems identification theory – not only to model structural performance and material characteristics in general, but also in the design of new special purpose materials.

In this project the challenge is to establish a fully consistent probabilistic model of structural materials which facilitate that material and structural performance can be quantified probabilistically utilizing information collected at different geometrical scales - ranging from nano to full scale. This necessitates that scalable probabilistic models are developed, tested and verified.

PD DTU Civil Engineering 5

Risk informed decision making on raw materials exploitation in Greenland

General societal pressure on the availability of raw materials such as minerals, critical and rare earth element as well as oil and gas increasingly direct attention on the prospects of exploration and exploitation activities in the high arctic. The effect of climate change on reductions in the extent and duration of ice coverage of the arctic seas add to the focus on the arctic regions for raw materials exploitation and shipping. On the one hand these developments open up opportunities for economic growth and improved welfare for the population in regions where at present livelihoods are under significant pressure and social problems are widespread. However, on the other hand raw materials exploitation is associated with significant risks to the fragile arctic environment, to the original cultures and as developments in many parts of the world have shown, may also lead to an unintended natural resource dominated economical dependency – with significant societal problems as a consequence – an effect which is also known as the resource curse.

Effectively the management of raw materials exploitation in arctic societies constitutes a new activity where not only the technical capabilities of various industries are pressed beyond their present level but also the related processes of societal planning and governance are pushed into new land. Considering the possible gravely adverse consequences which may be associated with these activities in especially the long term it is obvious that sustainable societal developments must take basis in a thorough understanding of all relevant risks and chances. In this project the aim is to establish quantitative models for the assessment of sustainability and risk which facilitates that sustainability and risks associated with different decision options/alternatives for the utilization of raw materials as a basis for the development of the Greenlandic economy and future welfare – with a holistic perspective to environment, economy, welfare and culture.

PD DTU Civil Engineering 6
Integration of framework and Open Platform design
The present activity together with activities PD 7 – PD 10 encompasses the central cross-going activity ithin the initiative Sustainability and Risk Informed Decision Making of developing a an Open Platform for the storage, organization and representation of data, information processing models, sustainability and risk metrics relevant for sustainability and risk informed decision support. In principle the platform to be developed will comprise a structured database with interfaces and defined formats for the inclusion of data, models, analysis and representation tools - objects. The platform will utilize to the highest degree possible generically formulated objects such as to enhance consistent modeling and unambiguous interpretation of representations of metrics of sustainability and risks and thereby to support consistent decision making across research fields. The open character of the platform not only gives private and public stakeholder access to data and models for practical application; it enables them to share their own data and models with the community. Possible application areas will include decision making in the context of management of risks due to natural hazards such as earthquake, typhoon and flood events, climate change adaptation planning with respect to e.g. extreme precipitation wind and snow events as well as risk management with respect to initiation and spread of food borne diseases.
The present activity will focus on the integration of the theoretical and methodical components which are developed by the other cross going activities of the initiative – ensuring that their interfaces are aligned and flexible and to establish a sustainable architecture for the Open Platform. The role of this PD in coordination with PD 7 will be the one of a facilitator for the project as a whole and will necessitate collaboration across the entire portfolio of activities in the project of cross going character.

PD DTU Civil Engineering 7
IT-Implementation of Platform

The present PD position will be devoted to the identification and development of IT solutions which will facilitate the actual implementation of the Open Platform as described in PD 6.
The IT infrastructure includes a back end (database) and a front end which encompasses editing tools (first reserved to project members; once the platform is established, open to everybody) and a web interface giving free access to the Open Decision Support Platform to public and private stakeholders around the world. The platform makes use of latest technological advancements, e.g. cloud computing. It should be noted that in this context no finished risk model is developed, but rather general guidelines for data and models, basic risk assessment algorithms, risk metrics and the IT infrastructure underlying the Open Decision Support Platform.The present PD will collaborate strongly with PD Byg 6 as design and implementation go hand in hand.

PD DTU Civil Engineering 8
Implementation and testing of platform - natural hazards
This task entails the application of the platform to natural hazard risk modeling. In a first phase, the team member in this position will be closely collaborating with PD 6 in the definition and requirements to the Open Decision Support Platform in regard to natural hazards. Thereafter, it involves the application of the developed platform to natural hazard risk assessment. The application will include the collection of natural hazard risk model available in literature and their adaption to the format and guidelines of the generic framework. Moreover, the task also entails the development of new indicator based natural hazard risk model. A dedicated target of the present PD will be to improve, adapt and implement existing models for earth quake risk management and typhoon risk management into models which may be included into the Open Platform. As an early user of platform

and generic framework, this role will be involved in the theoretical and methodical testing of the framework as well as the IT infrastructure.
This position is given a central role in promoting and popularizing the platform among the natural hazard risk assessment community.

PD DTU Civil Engineering 9
Implementation and testing of platform - food safety
This position will focus on the application of the platform to the domain of food safety and food borne diseases. The position resembles PD 8 as it takes an assisting role in the definition of the framework and it serves as an early user of the same. In a first phase, relevant indicator based risk models are collected, adapted to the generic framework and uploaded to the platform. Thereafter, new models can be developed. This position is given a central role in promoting and popularizing the platform among the food safety risk assessment community.

The simultaneous application of the framework to two different risk assessment domains, natural hazard and food safety, will help to keep the platform's framework and infrastructure truly generic and thus, valuable for a plethora of risk assessment domains.

PD DTU Civil Engineering 10
Critical Societal Infrastructures and indirect consequences
Indirect consequences of disruptive events, such as business interruption, loss of income, loss of access to utilities and basic services are painful byproducts of the event's direct consequences. This postdoc position will be responsible for establishing a methodological framework for the modeling of indirect consequences due to failure in critical societal infrastructure from disruptive events. As for the Open Decision Support Platform, the methodological framework should be general enough to allow its application for the analysis of disruptive events of different nature, e.g. natural hazard, terrorist attacks and pandemics, and provide the basis for consistent decision making. Critical societal infrastructure and its functioning is challenging to model, as it generally include a multitude of networks (e.g. transportation network, water supply, electricity supply) with numerous functional interdependences between them. An indicator-based risk assessment approach seems ideal for this task, as indicators allow summarizing the most relevant characteristics of complex systems in a compact manner. As such, a Bayesian approach seems particularly promising for this task.
Once the framework is established, the Postdoc will leverage it to develop different practical applications. For instance, possible applications include guidelines and best-practices for the design of robust critical societal infrastructure as well as a real-time decision model which can be applied after a disruptive event for the minimization of indirect consequences.

PD DTU Compute 1
Decision Rationale
The purpose is to develop a framework which enables comparison of the risks of consuming certain exposed food products. The intension is to support the decision makers in maximizing the benefit to society so food products will have a high quality and at the same time takes life quality and sustainability into account.

The food production is as today to a large extent optimized economically. It is however in a much less degree optimized according to 'quality of life' and socio-economic aspects. Certain food products pose a health risk and in order to compare the magnitude of the risk from these products a common

reference is needed. The reference could be a score which is composed of parameters describing health impacts, 'life quality' and socio-economic aspects. A decision on interventions can then be made according to the ranging of the scores and thereby maximizing the benefit for the society.

The scoring system can also be used when considering specific interventions within a food product. Especially in connection with risk assessment models the scoring system will be of great importance when considering different interventions which may not fully be comparable on a risk estimate alone. The change in score is estimated according to baseline and an estimate of the scenario 'if the intervention was implemented'.

Food products that pose a risk and that could be of interest to test and implement the system on is Campylobacter in chickens and/or antimicrobial resistance in slaughter pigs. For these products scores are being estimated based on the developed scoring system and further more models are developed to estimate the change in score due to certain interventions. For the 'Campylobacter in chicken' case a risk assessment already exists that could be of use when estimating changes in scores.

PD DTU Compute 2
[Titel ?]
A number of important techniques in analysis and optimisation of probabilistic systems are relevant for risk assessment and decision analysis. These techniques include various forms of stochastical modelling like Bayesian Networks, Markov Decision Processes, Control of Markovian processes as prominent examples. DTU compute currently covers many such techniques. It will be beneficial to make this knowledge base easier to access, and thus more operational, as well as to supplement the knowledge base to make it as complete as possible. Other methodological issues that will be addressed and included in a DTU "support kit" is a catalogue of uni- multivariate distributions with a classified particularly with respect to the application in modelling risk processes.

The knowledge base to be obtained in this activity will hopefully and most likely support DTU's activities within innovation. It is the goal that the centre construction should be knowledge-wise leading in Denmark, and among the best in Europe in the field of probabilistic modelling of engineering activities with special focus on sustainability and risk assessment. The activities in the post doc project will partly be to obtain, structure, and classify knowledge available in the open literature, partly to do research applying this knowledge within the case studies while enhancing existing models and methods developing new models and methodology.

The Unite project with participation by DTU Transport and DTU Compute, is among many projects at DTU compute related to this activity. Other examples include the MTlab project sponsored by the Villum Kann Rasmussen foundation and a number of consultancy projects carried out for DSB and Banedanmark.

PD DTU Compute 3
Uncertainty Analysis in LCA
In quantitative Life Cycle Assessment uncertainty is a very important issue that has been addressed in many papers in the last decade, e.g. in surveys like Finnveden, Hauschild et al: Recent Developments in Life Cycle Assessment (2009), or Heijungs and Huijbregts: A review of Approaches to Treat Uncertainty in LCA (no year given), and in analysis oriented work like Wang and Shen: A hybrid Data Quality Indicator and statistical method for improving uncertainty analysis in LCA of complex system –

application to the whole building embodied energy analysis (2013). However, there seemingly does not exist a systematic investigation on the relevance and applicability of modern data analytic and statistical approaches in this context. A person with a strong statistical background, rooted at DTU Compute, should elucidate the potential for theoretical and applied development in close co-operation with the other post docs. Apart from this targeted activity, a consistent treatment of uncertainties and other variability will be attempted as part of the quantitative assessment elements under all the post doc projects under this activity.

PD DTU Compute 4
Development of IT Framework for the Open Platform
The IT infrastructure of the Open Platform includes a back end (database) and a front end which encompasses editing tools (first reserved to project members; once the platform is established, open to everybody) and a web interface giving free access to the Open Decision Support Platform to public and private stakeholders around the world. The platform makes use of latest technological advancements, e.g. cloud computing. It should be noted that in this context no finished risk model is developed, but rather general guidelines for data and models, basic risk assessment algorithms, risk metrics and the IT infrastructure underlying the Open Decision Support Platform.

DTU Compute will be responsible for the development, implementation and systematical assessment of soundness and performance of the IT infrastructure underlying the Open Decision Support Platform.

PD DTU Food 1 og PD Food 2
The objective of these post doc projects are to provide a unified and transparent scientific basis for decision support which will facilitate decisions makers dealing with complex multidisciplinary problems, paving the way for a standardized approach. One post doc will study the life quality metrics, one will study the uncertainty analysis.

Activities: For both life quality metrics and uncertainty analysis, a comparison of methods will be a first step towards integration of the approaches used, and harmonization of metrics used across disciplines. ... Tasks in the post doc projects will be (1) review and compare existing methods, (2) develop a common approach including a specification of the necessary data and methods (3) develop a transdisciplinary DTU framework, and (4) apply the newly developed approaches on a case study in an area that is preferable multi-disciplinary across two or more DTU institutes.

PD DTU Food 3
Exploration of macroalgae as a novel sustainable biomaterial in food and feed production
Tang (makroalger) er en vigtig fødevareressource flere steder i verden (specielt Asien) og der er stigende interesse for at udnytte denne ressource også i den vestlige del af verden. Makroalger forventes at blive en global vigtig kilde til både humant konsum, til foderproduktion og andre biologiske produktioner. I Danmark er der igangsat flere initiativer med pilotprojekter om udnyttelse af tang herunder dyrkning og anvendelse i fødevareproduktion, men manglende viden om de forskellige tangarter, herunder deres fødevarekemiske sikkerhed, har bremset flere af initiativerne. Den manglende viden har bl.a. givet anledning til offentlige bekymringer i bl.a. medierne, ligesom erhvervet og myndigheder efterlyser et forskningsbaseret grundlag for retningslinjer til kommerciel anvendelse af tang.
Projektet vil bidrage med en videnskabelig funderet evaluering af de kemiske indholdsstoffer i udvalgte tangarter og stoffernes betydning for den videre anvendelse af tang som bæredygtig ressource i produktionen af fødevarer og foder. Både tangarter med potentiale for produktion i større

skala samt arter, som er mere velegnede til nicheprodukter vil indgå i projektet. Faktorer som geografi, årstidsvariation, artsvariation, produktionsforhold (f.eks. kombi-opdræt med fisk, muslinger og tang) skal indgå i evalueringen. Der vil blive fokuseret på tang-arter som allerede findes eller som har potentiale for dyrkning i danske/nordiske forhold.

PD DTU Man 1
Quantification of absolute boundaries for environmental sustainability
Topic: Analyse and develop quantitative estimates of sustainability boundaries for environmental pollution and damage in accordance with central sustainability definitions. The scope will be global for global impacts like climate change and depletion of non-renewable resources and regional for impacts like acidification, eutrophication, photochemical ozone, and toxic impacts to humans and ecosystems, and the outcome is a consistent set of absolute boundaries for environmental sustainability to be applied in sustainability of technology.

Rationale: When comparing technical systems, solutions or products in terms of their environmental sustainability, we normally decide whether one is more sustainable than the other and identify the main causes of environmental impacts. This supports development of more environmentally sustainable or eco-efficient solutions, providing the same or higher functionality at a reduced level of environmental impact, and in many areas the eco-efficiency of our technology is continuously increased. Overall such improvements are, however, often neutralized or reverted by increases in the consumption and use of the technology, and overall the development is not towards sustainability. We have to be able to assess whether the solution is sustainable in absolute terms and not just more sustainable than an alternative. To do so we need to determine the boundaries for environmental sustainability in terms of environmental limits that our society has to respect to stay within a safe operating space for our civilization.

Anchoring: The Post doc will be located in the post doc centre of the initiative and scientifically rooted in the sustainability assessment activities of DTU MAN with co-supervision from DTU ENV
DTU MAN has a PhD student working in the field and has established collaboration in the field with KU's Sustainability Science Centre, Stockholm Resilience Centre at Stockholm University and University of Toronto (chemical footprints and global boundaries for chemical impacts).

PD DTU Man 2
Integration of the three sustainability dimensions – weighing and aggregation of sustainability scores
Topic: Development of a structured and consistent set of procedures for ranking, weighing and combining scores for each of the three sustainability dimensions to arrive at an overall conclusion of which alternative has the best sustainability performance overall. To reflect that variability in the integration, the preferences are analysed for the different definitions of sustainability and determined for the different central stakeholders of the analysed systems. Monetarisation is examined as a way of expressing the resulting weights quantitatively for each of the sustainability dimensions. In addition to this form of weighting also semi-quantitative approaches like multi-criteria analysis and outranking procedures are investigated.

Rationale: Separate metrics are developed to express the performance for each of the three dimensions of sustainability – the environmental, the social and societal and the economic. They are thus not immediately comparable, and in many cases there will be tradeoffs between the three dimensions so the preferred solution from an environmental perspective is not the preferred from an

economic or social perspective. Different sustainability definitions may give different preferences, and the synthesis into one overall conclusion regarding which is the most sustainable solution must take this into account and reflect it in the uncertainty accompanying the conclusion

Anchoring: The Post doc will be located in the post doc centre of the initiative and scientifically rooted in the sustainability assessment activities of DTU MAN.

DTU MAN has on-going activities on integrated sustainability assessment of future technologies in the FP7 programme PROSUITE and through this project has a good network to some of the leading European research institutions within the field.

PD DTU Man 3
Sustainable Development and Risk Based Decision Support
The post doc will develop a methodological approach and a modeling tool that can be used to frame risk based decision support in the context of sustainable development. Sustainable development as a concept involves some particular challenges for decision making including issues related to uncertainties and a long time horizon emerging from intergenerational equity aspects, the use of exhaustible resources, and from global environmental impacts like climate change emerging over centuries. Managing global commons like the climate, biodiversity, bio-resources, and the oceans, furthermore raises a number of governance issues, which need to be addressed in a consistent and transparent way in decision making at different scales including international fora, and regional-, national-, and local institutions. The activity will develop a methodological framework that can be used to add the sustainable development dimensions to decision analysis at different scales, indicators for quantitative assessment of sustainable development dimensions at societal level will be suggested based on input from Activity C, and a modeling tool will be developed and applied to evaluation of a number of parallel case studies at different scale and for different geographical locations in order to derive a generic approach for consistent sustainable development based decision frameworks. A potential case study is bioenergy use, production, food security, and health implications. Such a case study will involve the consideration of long term uncertainties of climate change, impacts on bioenergy production and food systems, equity aspects and global sharing of resources and windfall profits of high bioenergy demand, as well as a number of social aspects related to employment generation and health.

PD DTU Man 4
Uncertainties and Risk Preferences
Decision making frameworks are often based on policy targets and objective functions with arguments that represent expected direct- and indirect impacts of implementing specific technologies and policies. The objective function structure is influenced by a rational planning model, where it is assumed that the individual arguments in the function easily can be represented by monetary values or other quantitative date, and an optimal expected risk metric then can be generated as a basis for decision making. Major risks as for example related to extreme events like natural disasters, health epidemics, and extreme weather, however cannot in a meaning full way be represented in such an objective function for decision making. Such risks can have a low probability, but the consequences can be high to nature, society, and individuals, and can include aspects characterized by strong risk aversion. The post doc will develop a methodological framework for the integration of uncertainties and risk aversion in objective functions applied to decision making for high consequence events. A model will be developed based on probabilities of high consequence events, and risk attitudes towards these events. Stochastic modeling will be used to derive probability density functions for high impact

events, and literature studies, and indirect benefit transfer approaches for revealed risk preferences, will be used to estimate risk preferences and certainty equivalent values for risk aversion. The modeling tools will be applied to the assessment of the risks of flooding events including natural disasters like the Tsunami and weather impact events like the recent flooding in Europe and evaluated against observations of the occurred damages. Following that, decision making on coping strategies will be assessed in the context of the efficiency of risk communication strategies and disaster management.

PD DTU Man 5

Modeling the life cycle impacts of emerging technologies

When the sustainability is compared for emerging technologies and current technologies, the comparison is biased by the fact that while current technologies operate at commercial scale and have reached high level of maturity through years of optimization, the emerging technology may only exist at pilot or lab scale and its performance at commercial scale is difficult to predict based on measurements in the small scale. To assess the improvement potential of the emerging technology we need to develop and apply methods for upscaling and predicting efficiency improvement potentials e.g. based on learning curves from other domains. Furthermore potential changes in the background system as a consequence of the technology shift need to be identified and assessed to give a relevant assessment of the sustainability impacts of shifting from the current to the emerging technology.

PD DTU Man 6

Impacts from chemicals and toxic emissions

Emissions from the life cycle of a product or a technology can contribute to various categories of environmental impacts, among which in particular two are difficult to quantify. We apply ten thousands of chemicals many of which have the potential to cause damage on ecosystem functions or human health. Methods exist to model and quantify these damages, but the substance data needed as input to these models is missing for the vast majority of substances and overall only a minor part can be included in the impact assessment. Tools are needed to prioritize among the chemicals and estimate the needed substance properties and calculate the assessment factors used in LCA.

PD DTU Man 7

Social and economic dimension of LCA

The social impacts of a technology often depends at least as much on the societal conditions under which it acts, and the behavior and values of the companies that apply it as it does on the inherent properties of the technology itself. Nevertheless, a full sustainability assessment must include the social impacts together with the environmental impacts in a life cycle perspective. The postdoc will identify the most important types of social impacts in relation to technologies, identify the main drivers behind the impacts in a life cycle perspective and develop guidelines on how to represent them in a combined quantitative and qualitative assessment. Overlaps between the economic dimension, the resource impacts of the environmental dimension and the social dimension will be identified and guidance on how to understand the economic dimension and quantify it in relation to a technology will be developed.

PD DTU Environment 3

Climate change adaptation in relation to urban water management

All three dimensions of sustainability (social, economic, and environmental) are currently being threatened by the observed increase in climatic extremes. Climate projections foresee that the increase will continue in the decades to come and hence it is of paramount importance to identify

measures that enable transition to more resilient cities. The same projections also foresee summers that are in general warmer and drier, and hence it becomes more important to retain water to preserve livability by utilizing the obvious amenity values of water while minimizing the risk of damage due to climatic extremes.

Current state-of-the- art risk analysis comprise an analysis of one hazard at a time (precipitation, sea surge, groundwater, or river) of a city assuming stationary hazards and vulnerabilities. There is a need to develop concepts and models that enable analysis of multiple hazards concurrently and an integration of non-stationary behavior and both epistemic and aleatory uncertainty into decision making. Also, the risks must be balanced with the potential amenity value of utilizing the water for recreational and other purposes in the cities.

The tools that must to be developed to meet the needs of society are generic to several types of infrastructure that must be designed under high uncertainties in a non-stationary environment. Hence the topic can be extended to encompass research areas such as off-shore structures, roads, bridges, and buildings.

Non-stationary risk analysis, urban drainage, infrastructure, sustainability.

PD DTU Environment 4
Renewable resources, water and land
The impacts caused by water use and land use are potentially important for all technologies based on biological resources, and they are among the strongest environmental impacts in terms of the damage that they can cause to natural ecosystems and human health (through lack of access to water). They both have a strong local or regional dependency which must be taken into account in assessing the impacts that they cause on the environment, and their ability to cause damage to the natural ecosystems and to human health must be assessed in a quantitative way to enable their inclusion together with other environmental impacts in a quantitative sustainability assessment.

PD DTU Environment 5
Non-renewable resources
The access to non-renewable resources is a pre-requisite for both current and future generations' ability to fulfill their needs and apart from that today an important strategic factor in determining industrial competitiveness in different parts of the world. The impacts of a technology or product on the depletion of non-renewable resources is therefore an important parameter in the sustainability assessment that needs to be quantified in a way which allows it to be taken into account together with the environmental impacts.

PD DTU Space 1
Advanced Receiver Autonomous Integrity Monitoring (ARAIM) methods for assessing the integrity of global positioning systems in Arctic
The Advanced Receiver Autonomous Integrity Monitoring (ARAIM) method is a consistency check to protect primarily aviation users against incorrect position estimation during landing and en-route flight. The performance of this monitoring is highly dependent on the assumptions of the GNSS satellite and constellation faults, which may occur with certain probabilities during the processing time. In Arctic regions the variability of the ionosphere and the availability of only coarse time information in ground receivers have limited the reliability of the existing systems (developed for GPS, WAAS, and EGNOS). ESA has initiated studies and projects to develop a next generation approach for aviation in Arctic.

Together with other European universities and companies DTU Space is performing initial studies of ARAIM for the GALILEO satellite navigation system and EGNOS. The postdoc will complement and extend the ongoing ESA project in relation to the development of new algorithms, demonstrations and verifications. The postdoc will address:

- Definition and optimization of statistical ARAIM user integrity algorithms and the identification of minimum requirements for an ARAIM reference algorithm. The analysis of the compliance of current and future statistical algorithms and solutions, taking into the ARAIM processing requirements.

- Implementation and testing of optimal ARAIM algorithms in the ESA Galileo System Simulation Facility (GSSF).

- Initiate demonstrations in relation to the ESA GALILEO Arctic TestBed program element and cooperation with Air Greenland.

PD KT 1
Quantitative risk and uncertainty analysis for complex chemical engineering systems – a risk based decision support tool
The purpose is to develop a generic framework for effectively addressing the issue of uncertainties and risks related to design of chemical processing networks and its implementation as a decision support tool for facilitating risk-averse and robust chemical industries

In general terms, a chemical company is an enterprise which operates the business of transforming raw materials into value-added products, through a series of physical and chemical operations, which constitutes a chemical process. The optimal design of a processing network is a complex and multi-disciplinary decision-making problem, which requires the integration of a number of different disciplines and knowledge from chemical engineering to marketing, financial, supply chain,etc. Moreover, at the time the design decisions are taken there is considerable uncertainties in multidisciplinary data and knowledge -only hypothesis can be made on the value of these data, based upon past and current observations (e.g. market fluctuations of a product, technical parameters, etc). Therefore the activities in this project will focus on developing a generic framework to manage the uncertainties and minimize the risks at project design phase through identifying and implementation of strategies aiming at minimizing or mitigating the potential negative consequences on the performances of the processing network. To this end, the workflow and dataflow in the problem formulation will be identified and a decision support tool is to be developed, together with all the needed models, uncertainty and risk analysis methods, tools and solution strategies. Finally, application of the workflow together with the decision support tool for risk-averse and optimal design of complex chemical systems will be highlighted through case studies including design of sustainable chemical process in particular design of biorefinery networks employing thermo-chemical as well as biochemical conversion platforms to make sustainable biofuels and bioproducts.

PD DTU Aqua 1

Long-term predictability of marine ecosystems and its implications for management support

The purpose is to improve decision support in relation to sustainable exploitation of marine living resources. Sustainability is a strategic priority for DTU. The activity will advance the state of the art within research-based public sector consultancy.

Long-term predictions of ecosystem dynamics is being used as part of management strategy evaluation, typically by simulating scenarios and assessing risks of unsustainability, for example in the context of fisheries management. A key issue is the uncertainty on such long-term predictions. This uncertainty stems from limited knowledge about both model structure and model parameters. In particular, some ecosystems have only been monitored extensively for a relative short time compared to prediction horizons, and some scenarios take place in different dynamic regimes than those where historical data has been collected; both issues severely impair predictability.

This activity aims to improve the value of long-term predictions as a decision support tool, by developing methods which quantify the uncertainty on predictions, identify which model components contribute mostly to prediction uncertainty, and reduce prediction uncertainty. Key elements are the robustness of estimators, and the integration of prior mechanistic knowledge about processes with statistical time series analysis, following the ”grey box” paradigm.